ETHER ANÆSTHESIA; CLINICAL NOTES ON THREE HUNDRED CASES.

By G. GORDON CAMPBELL, M.D.,

OF MONTREAL,

ASSISTANT DEMONSTRATOR IN MEDICINE, McGILL COLLEGE; ASSISTANT PHYSICIAN, MONTREAL GENERAL HOSPITAL.

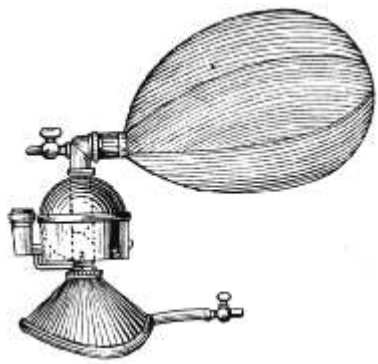
THE additions of late to the literature of anæsthesia have been so largely through experimentation on the lower animals that, in treating the subject from another stand-point,—that is, from observations made by the anæsthetist at the bedside and at the operation table,—I have ventured to think we may obtain some valuable information. As a great part of my work depends, both in the results achieved and in the possibility of recording them correctly, upon the form of inhaler used, a description of it will be in order first.

The instrument used throughout was Clover's ether inhaler, well known and popular in England, but not so widely known on this continent as it deserves. The principle on which it is constructed will be easily understood from the following description taken from Joseph Mill's article on anæsthesia in Treves's "Manual of Surgery" and from the accompanying cut.

"The inhaler consists of a face-piece with an indicator, which, by rotation, may be made to point to 0, 1, 2, 3, or F, on the circumference of a metallic vessel containing fluid ether; and of a bag, into which and from which the patient breathes. It is so constructed that when the indicator is at 0, the expired and inspired air passes to and from the bag, without in any way communicating with the ether-chamber. If the indicator stands at F, the whole of the expired air must pass through the ether-vessel to the bag, and at inspiration return from the bag through the ether-vessel. When the indicator is at 2, half the respired air passes to and from the bag direct; the other half passes through the ether-vessel; and so on for the other

numbers. The air does not pass through the ether, but simply through the vessel containing it, and this is sufficient to carry off a large amount of its vapor." A slight addition has been made to the instrument lately in the form of an elbow, which allows the face-piece to be coupled to the ether-reservoir at right angles, if necessary, so that the ether-reservoir can still be kept horizontal with the patient lying on the side.

The Method of Administration used.—Before beginning, I always explain to the patient the possible disagreeable effects of inhaling ether, its pungent, irritating vapor, and its tendency at the outset to cause coughing and choking sensations; I take care, at the same time, to let it be understood that I shall endeavor to prevent these undesirable effects, as far as possible, by allowing



Clover's Inhaler.

frequent breaths of pure air, if necessary. The pillows are so arranged that the patient's head is low and in a line with the body,—that is, as it would be held in standing, and not at an angle with the thorax. as it usually is while lying in bed. An ounce and a half, fluid measure, is put into the reservoir, and it is rotated so that the indicator points to O. The patient's eyes being closed, the inhaler (with the tap attached to air-cushion of the face-piece open) is placed on the face and tilted away from the chin so that the mouth is left free; the patient is then directed to take several deep breaths, and the face-piece lowered in time to catch each expiration, and raised again at inspiration; and thus the bag is filled with expired air. The tap of the air-cushion is closed while the inhaler is pressed against the face

during expiration. The patient is now directed to breathe quietly; and the ether-reservoir is turned so that the indicator points to about one-fourth of the distance of 1 from 0; which means that the patient is getting about 5 per cent. of ether vapor in the air breathed, reckoning as 100 the proportion of ether vapor which will be mixed with the air, when the indicator points to F.

As usually happens, after several deep breaths, the succeeding ones are shallow as compared to the normal; and thus a very small amount of ether vapor is inhaled at the outset, and its irritating effects are reduced to a minimum. After a few breaths, and before there can possibly have been any sensation due to the deprivation of pure air, one end of the inhaler is raised and the patient allowed an inspiration from without; and then the reservoir is slowly turned, so as gradually and imperceptibly to increase the strength of ether vapor in the air breathed; a breath of pure air from without being given every now and then, as the want of it is seen to be causing distress. At the first sign of intolerance, such as swallowing, raising the hand, or ceasing to breathe, the inhaler is raised and the patient directed to take a deep breath; and if this fails to produce the desired result, the reservoir is turned back so as to diminish the strength of the ether vapor. On again increasing its strength care is taken not to exceed the limits of tolerance. Very soon a stage is reached at which the patient seems to fall asleep, and regular deep breathing ensues; there being either an extremely slight stage of excitement, or more frequently none at all. I call this the sleeping stage, because the patient is, to all intents and purposes, in the condition of deep sleep, and not of surgical anæsthesia. Once this stage has been reached, however, the strength of ether vapor can be quickly increased; and full anæsthesia, with loss of the corneal reflex and general muscular relaxation, rapidly ensues. By following strictly this method, I have had but two cases of struggling or screaming in 300 administrations, —that is, less than one in a hundred of my patients has required to have even the hands held, for purposes of restraint, while taking the anæsthetic. This is undoubtedly a very low propor-

tion, even under the most favorable circumstances; and I think no stronger argument can be adduced in favor of the induction of anæsthesia by gradually increasing the dose of ether as compared with the method of giving it by keeping a saturated sponge or gauze a few inches from the patient's nose, and, as is too often the case, causing all the symptoms of strangulation.

The circumstances and surroundings in which most of my cases were placed are, I think, the most favorable in some respects that can be attained. With a few exceptions, twenty in all, my patients were adult females of the upper classes, prepared for operation in a private hospital, and the ether was given in the patient's own bed.

In my own experience, the better educated and the more intellectual people are, the more confidence they have in the anæsthetist, and confidence goes a long way in keeping up one's courage when one feels one's self gradually passing into the realms of unconsciousness. This favorable element, however, was offset to a great extent by the large proportion of extremely nervous people met with among those requiring gynæcological operations, people who easily lose control of their actions and emotions. It must not be understood that all cases are as easily managed and go under ether as readily as described; a great many nervous people, who have "screwed their courage to the sticking point," lose all control of themselves after the administration has once actually begun and commence to either struggle or scream or more often to do both before they have had more than a few whiffs of ether. With these the proper plan is to at once remove the inhaler altogether and state plainly that you cannot proceed until quiet is restored, at the same time assuring the patient that if your instructions with regard to taking the ether are adhered to there will be no necessity for any screaming or struggling, but that she will drop off to sleep quietly; and then on recommencing the administration there is no further trouble. This plan answered ten times in the last 100 of my cases and failed but once, and I believe a possible explanation of the change in the patient's behavior is this: that the fear, or whatever emotion caused the excitement, is replaced by indignation at the

anæsthetist's supposed want of sympathy with one who, in all probability, has been doing her best to control herself. The fact that the most of these patients on recovering from the anæsthetic expressed themselves as indignant at the manner in which they were treated bears this out. In other cases, again, control is lost just before the stage is reached at which it is possible to push the ether more rapidly, and two or three breaths then serve to quiet all struggling.

Of the two cases in which I failed to produce anæsthesia without struggling, I endeavored three times in one, by abruptly ceasing the administration and waiting until I could get rational answers to my questions before going on, to do without restraint, but failed. In the other, the patient informed me that she had taken ether several times, and always "screamed herself off," so I made no attempt to combat her resolution.

It occasionally happens that a state of tonic contraction or spasm of the whole body comes on along with full anæsthesia instead of the usual relaxation. This occurred thirty-four times, or in 11 per cent. of the cases.

An explanation of this I am not prepared to give, but it may be noted that when the anæsthesia ordinarily is not yet quite fully established, and also when it is commencing to pass off, there is almost always found to be exaggeration of the patellar reflex and ankle and rectus clonus. And, moreover, clonic contractions of an individual muscle or limb tend to become general in character; thus elevating the leg by placing a finger under the heel often sets up a fine tremor of the whole limb, and tapping the triceps tendon in the arm brings out the same phenomenon in that member. In the same way spasm of the glottis, due to the direct irritation from ether vapor, may, during a late stage in the production of anæsthesia, spread from this as a centre over the whole body and cause general rigidity. Quite apart from this theory as to its cause, the fact has been noted that this condition of spasm is more apt to occur in those subjects exhibiting greater irritability of the mucous membranes to ether vapor. Added to this is the fact that pushing the ether does not overcome but prolongs the rigidity, whereas withdrawing it altogether soon brings

about relaxation of the muscles without return to consciousness. This point was determined experimentally in half a dozen cases by pushing the ether, or at least not decreasing the proportion of vapor breathed, for from twenty to twenty-five minutes, and in all cases the rigidity persisted until the ether vapor was either wholly withdrawn or greatly diminished in strength. Hence the proper procedure on the occurrence of spasm is to discontinue the administration until it passes off, and begin again with a lessened percentage of vapor. It very rarely ever recurs.

Very much less ether is required to keep up anæsthesia than to induce it, hence, as soon as the patient becomes fully anæsthetized, the indicator is allowed to point midway between 1 and 2, and one inspiration of pure air given to every two from the bag; and, as time goes on, the proportion of ether is decreased and of pure air increased. In the majority of cases full anæsthesia is reached when the patient is breathing from 50 to 75 per cent. of ether vapor in the air,—that is, with the indicator between 2 and 3. The percentage reached is higher in winter than summer, owing to the slower rate of evaporation at lower temperatures.

In most forms of the inhaler there is a closed water-chamber below the ether reservoir, and by standing the cylinder for a few minutes in hot water this can be heated sufficiently to warm the ether vapor in cold weather.

The Length of Time Required to produce Full Anæsthesia.—In considering this point the time is calculated from the moment the inhaler is applied to the patient's face until full anæsthesia is produced. The average time for the whole 300 cases is 4.8 minutes, the longest being twelve minutes and the shortest two minutes.

Thus in 62 per cent. of the whole number the time required was under five minutes, and in 80 per cent. under six minutes. These figures do not represent the actual time elapsing in producing anæsthesia while the patient is breathing the ether, but include all those cases in which, as before described, the administration was temporarily ceased. Undoubtedly if screaming and struggling were ignored and the anæsthetic pushed, as in dealing with children, the average time would be shortened considerably.

I have been unable to obtain any exact statistics of the time required in other forms of inhalers, but from my own experience I judge it is considerably shorter on the average with the Clover than with the others. Of the causes tending to prolong the time beyond the average the chief one was loss of control on the patient's part, as already referred to; another, difficulty in getting the patients to breathe properly, owing to their timidity; and lastly, a badly-fitting face-piece, which allowed air to enter between it and the face, so that very little of the respired air passed through the ether-vessel. This can be guarded against by having several different sizes of face-pieces, and by allowing sufficient air to escape from the air-cushion so that it adjusts accurately to the face when pressed down.

The following table (No. I) shows the details:

TABLE I.

Two minutes and under three					6 =	2 per cent.
Three	"	"	four		60 = 20	"
Four	"	"	five		118 = 40	"
Five	"	"	six		58 = 20	"
Six	"	"	seven		19 = 6	"
Seven	"	"	eight		16 = 5	"
Eight	"	"	nine		10 = 3	"
Nine	"	"	ten		2	
Ten	"				7	
Eleven and twelve minutes					4	

The Amount of Ether consumed.—This is obtained by comparing the average time under anæsthesia with the average amount of ether used. The time is reckoned from the moment the inhaler is first applied to the face until the administration is stopped, although the anæsthesia lasts for a variable length of time after this. The average length of administration was eighty-seven and a half minutes, and the average of ether forty fluid drachms for the 280 cases of which I have notes; or, in round numbers, five fluid ounces of ether, or about the amount in an ordinary 100-gramme tin, sufficed for an administration lasting an hour and a half. The amount varies relatively in inverse proportion to the length of administration thus, for those operations lasting three hours or over, ten in all, the average amount of

ether used in an hour and a half was only twenty-eight fluid drachms as compared with forty. About four fluid ounces, as a rule, should be allowed for the first hour, two and a half for the second, and so on in proportion. There is, too, roughly speaking, a direct proportion between the body weight and the amount of ether used, but this is often disturbed by other causes of which, perhaps, individual idiosyncrasy is the prominent one. Anæmia appears to be a factor tending to diminish, and plethora one tending to increase the amount necessary to keep up anæsthesia.

Vomiting During the Operation.—This occurred seventeen times, or in 5.6 per cent. of the cases. Its occurrence, though of little moment in the majority of surgical operations, often greatly increases the danger of spreading infection where there is a localized collection of pus within the abdomen. The determining cause in many of these cases could not be satisfactorily fixed; in one or two it was partial recovery from anæsthesia through faulty administration, in others I fancied that swallowing air before almost every breath, while going under, accounted for it.

After Vomiting.—This is the point on which I have obtained the least satisfactory results. Nausea or vomiting occurred in 90 per cent. of all cases. Several of the methods recommended for modifying this untoward effect of ether were tried, but without success. Atropine, either alone or with morphia, was tried both hypodermically and by the mouth, but without satisfactory results; and, besides, it disguised the real condition of the patient by its influence on pulse, pupils, and respiration. For this reason, as will be shown in speaking of pulse and respiration, I consider it is contraindicated. Possibly the relatively long duration of the series of cases under discussion in this paper as compared with operations in general may account for the large amount of after-sickness noted.

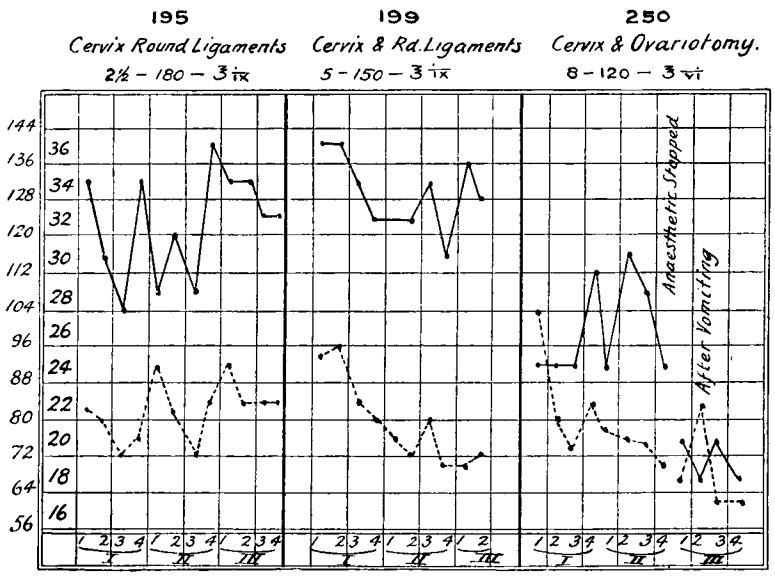
Pulse and Respiration.—Plastic operations certainly give one the best opportunity of investigating clinically the effect of ether upon the pulse and respiration. In a case, for example, of repair of the perineum, where there has been normal temperature, pulse, and respiration, and where the operation itself does not produce any shock from hæmorrhage or other cause, all changes in these

must be due entirely to the ether inhaled. In order to determine as far as possible the usual effect and to detect any causes tending to alter this, the pulse and respirations were taken every fifteen minutes throughout the anæsthesia in 100 cases; and in a large number of these, for the hour following also. From the data thus obtained are prepared pulse-respiration charts, the ratio being the usual one of four to one. As the pulse is usually extremely rapid at the outset, from the excited condition of the patient, the first time recorded is at the end of fifteen minutes, marked on the chart as 1; 2, 3, and 4, thus representing the half hour, three-quarters, and hour, and so on for the other hours.

The general course of the pulse shows an initial rise above the normal of from thirty to seventy beats a minute, caused by the excitement and the stimulating action of the drug; then a gradual fall amounting to twenty or thirty beats by the first quarter and continuing, so that at the half or three-quarters it has reached the rate normal to the individual, at which it remains. The respirations are also at the outset greatly increased, but they do not fall with the pulse and do not come down to the normal rate, while the ether continues to be inhaled; thus the pulse-respiration ratio is altered from four to one, to three or two to one. The rate of respiration is usually between twenty-four and thirty-six, but it is liable to rapid alterations.

Now the question arises, whether we can lay down any fixed rule for the pulse and respiration rate, and the ratio between the two, of practical value, so that variations from this may be accepted as evidence of some cause, acting either in the way of faulty administration or in the operation itself, which is affecting the patient's condition. I think we can, but before discussing the subject it is necessary to refer again to the inhaler, with which, as previously stated, the strength of ether vapor inhaled can be regulated at will by the anæsthetist. It is claimed by some writers, however, that a definite proportion of the effect produced in this method of administering ether is due to the production of a certain degree of asphyxia by breathing over again already respired air along with the ether vapor, and it is this point I will

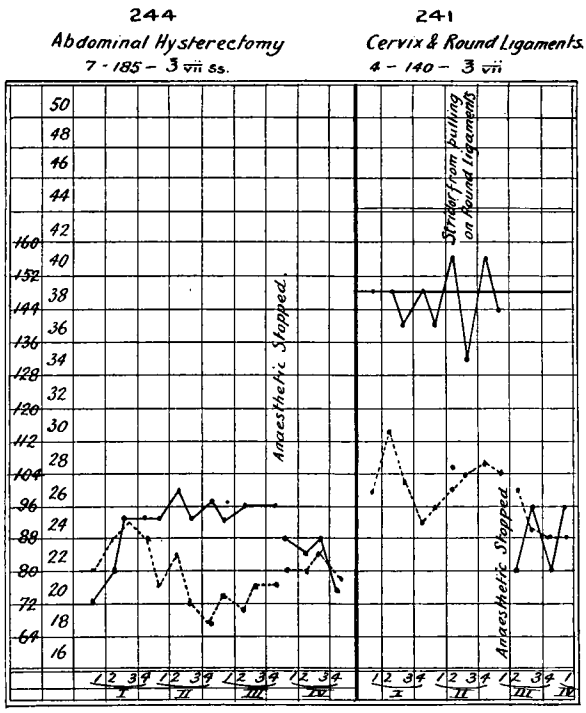
now consider. I admit that the production of anæsthesia by this method is due to ether plus a certain amount of asphyxia ; I hold, however, that the method of giving the ether followed after anæsthesia has been set up, practically eliminates entirely any element of asphyxia then. It was in this order : one inspiration and expiration of air, inspiration of air, expiration into the bag, inspiration from and expiration into the bag, and so on over again. Thus, in every three respirations, two inspirations were of air and one from the bag, and in other cases, in every four breaths, two



were of air ; moreover, the air in the bag is replenished each time by an expiration containing the amount of pure air in the respiratory passages at the end of inspiration, as this must first be driven out before the foul air from the lungs can follow it. The air in the bag is thus diluted with a certain amount of good air before it is drawn into the lungs, and as at least half of all breaths are pure air and the breathing is double the normal rate, the degree of asphyxia must be practically *nil.* I have, too, in a measure, tested the matter practically by comparing two series of ten administrations each, of which the aggregate time in

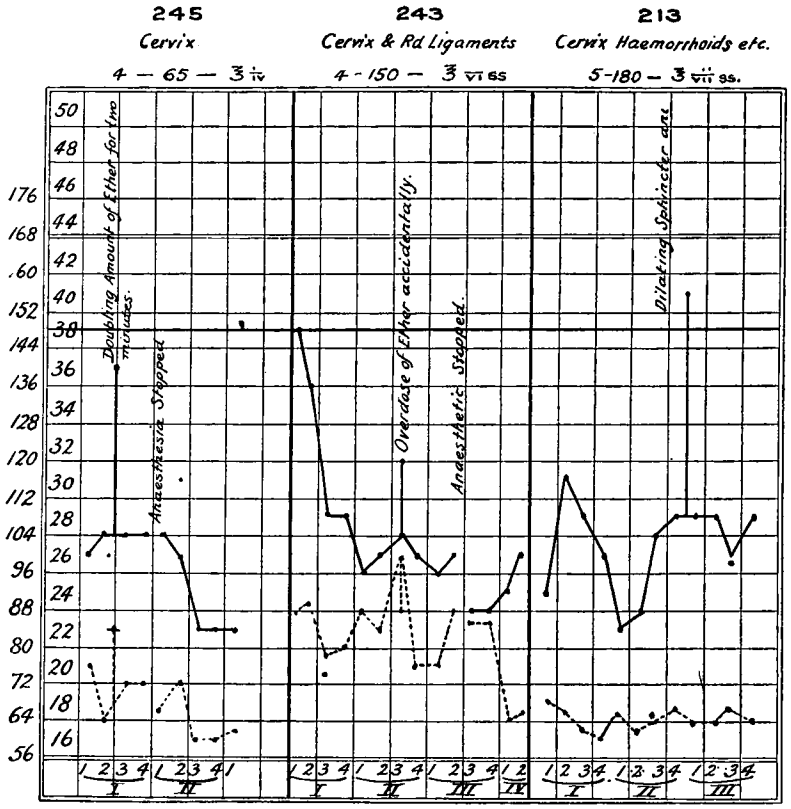
both was the same, in one series the ether was given in the ordinary manner, in the other with much less pure air, and there was only the difference of a couple of drachms between the amounts of ether used in each series.

Purposely taking a class of cases in which we may reasonably expect the nature of the operation to have little effect upon the condition of the patient, and selecting from among these the ones in which the anæsthesia was kept up for the longest period,



we find, in cases 195 and 199, lasting three hours and two hours and a half respectively, that the pulse does not become faster as the time progresses, but remains at about the normal. The respirations vary between twenty-eight and thirty-six, but evidently the variations do not correspond with those of the pulse. Chart 199 shows, moreover, the gradual fall, as described, at the beginning of the administration; and both show the alteration in

pulse-respiration ratio. In Case 250, where the abdominal cavity was opened, and hence the operation was of a more serious nature, the pulse chart shows the same general course and the respirations are also increased, and the pulse-respiration ratio altered. As soon as the ether is stopped, however, the normal ratio is re-established. I have, besides the ones shown, twenty-five



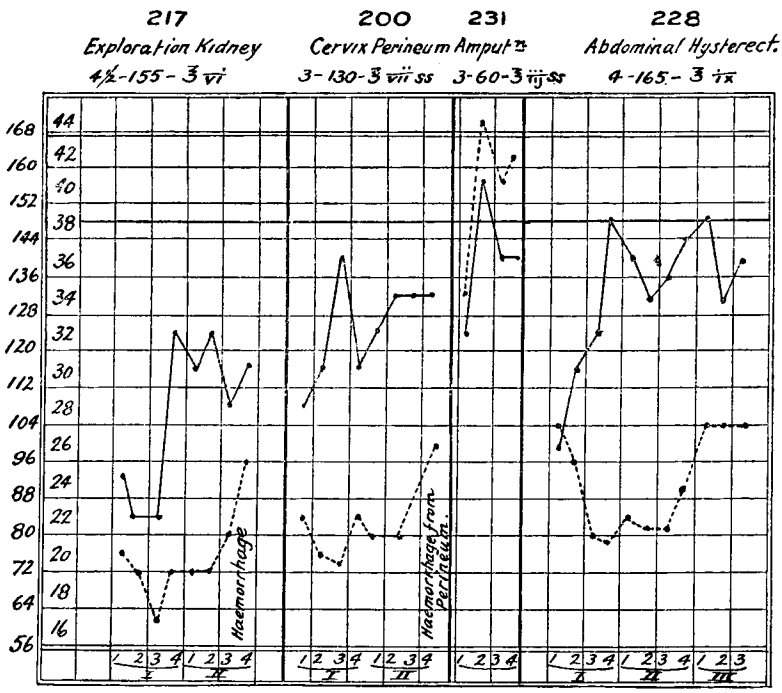
similar charts, all showing the fall in the rate of the pulse at the outset, and then no further tendency to rise above normal limits.

Case 244, although a very serious operation,—viz., total extirpation of the uterus, in which the anæsthesia was kept up three hours and the abdominal cavity was open for over two,—shows no rise of the pulse above 92, and at the end of the three

hours it was 76, and full and strong in character. Case 241, again, appears to be due to an individual peculiarity of which I will have something to say later.

Another series of charts shows changes due to various causes. These are,—

(1) Changes, both in pulse and respiration, from an overdose of ether,—*i.e.*, more than is required to keep up surgical anæsthesia.

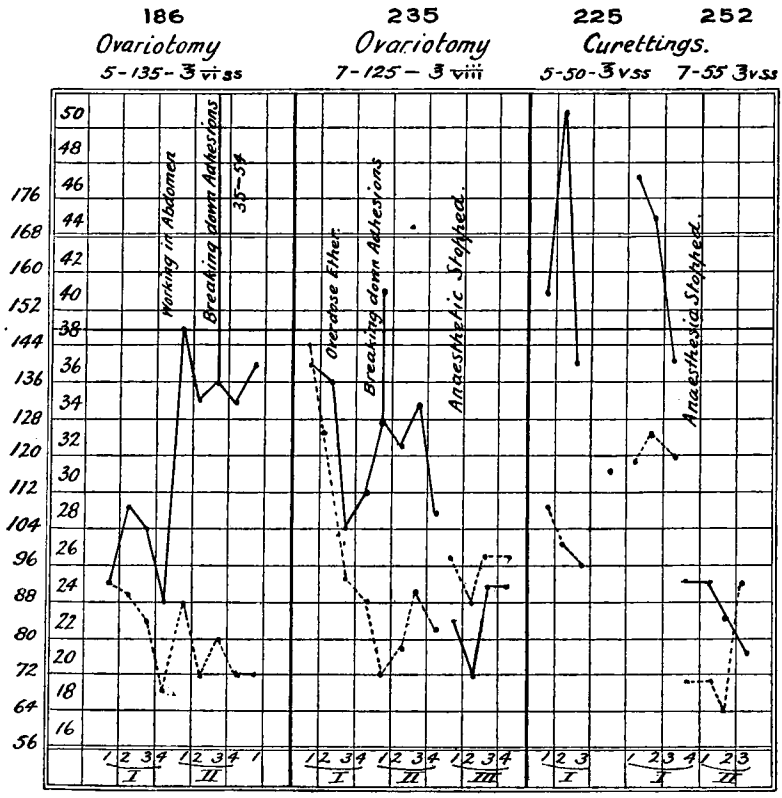


(2) Changes in the pulse from loss of blood.

(3) Reflex quickening of the respirations from various manipulations on the part of the operator.

The effect produced by an overdose of ether was obtained experimentally as follows: With the breathing and pulse at what was the best obtainable for each individual case, the strength of ether vapor was doubled, but given with exactly the same proportion of pure air, in ten cases, and the results noted. These

were: a sudden rise in the rate of respiration of from 10 to 14 per minute with stridor and labored breathing; a less marked rise in the pulse-rate of from 12 to 20 beats; and dilatation of the pupils. On allowing the patient to breathe pure air for a short period almost as sudden a return to the former rates was noted. See Cases 245, 247, and 248, which explain themselves. Experi-



ments of this nature can, of course, only be carried on within very narrow limits, but enough has been shown to prove that an overdose of ether can cause an alarming change in the condition of the patient, and so lessen the resisting powers. Acting on the knowledge gained through this experiment, I have several times been able to detect an overdose in my own cases, and, by

decreasing the strength of ether vapor, to better the condition of the patient. Case 243 is one of those alluded to.

The effect of hæmorrhage is shown in Case 217, where an unusually slow pulse rises from 72 to 96 from free bleeding from an incised kidney; and in Case 200, where there was smart hæmorrhage from the perineum. In both of these cases, and in others to be referred to, the possibility of the effects noted being due to an overdose of ether was first considered and tested. Case 231 shows an extremely rapid pulse-rate, the relative position of pulse and respirations having changed. The case was one of amputation of the thigh in an old woman weakened by suppuration of a joint. The pulse-rate before operation was for days over 120, and there was considerable pyrexia. There was no loss of blood, and the case did well. I introduce it here to show that any observations forming a basis for generalizations must be made on subjects who are in normal health at the time of operation.

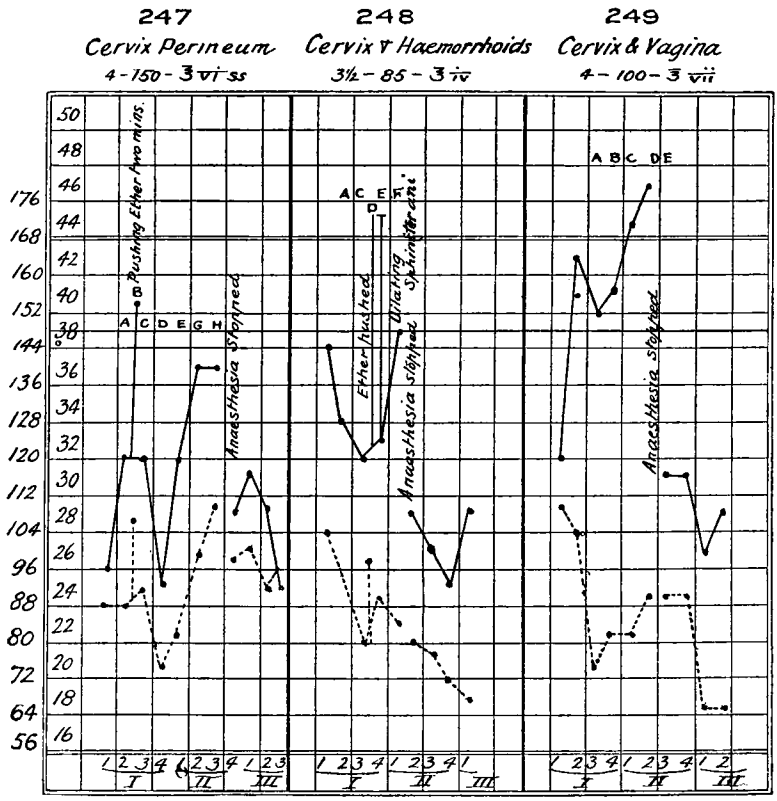
Another series of cases shows the effects produced upon the respiration by various manipulations on the part of the operator. In almost all articles upon anæsthesia one sees the statement made that a much deeper degree of anæsthesia is required for operations upon the perineum and rectum than in other cases. The reason for this opinion is evident. Reflexes persist from these parts when all others are abolished. These reflexes, however, I can show, affect only the breathing, and not the general condition of the patient. The manipulations which affect the breathing are, stretching of the sphincter ani and working with the mucosa of the rectum, rough handling of the peritoneum, and especially breaking down peritoneal adhesions, compression or rough handling of the ovaries and testes, and stretching of the perineum. The latter is not so invariable as the others. Take, for example, Case 213. Here, with respiration 38, pulse 66, dilating the sphincter ani caused a sudden rise to 40 of the respirations, with marked stridor, and no change at all could be detected in the pulse or pupils. This observation has been made over twenty times. The same thing is seen in Case 248. Case 186 shows the effect of breaking down peritoneal adhesions. Although the respirations shot up at once when tearing away the

ovaries from firm adhesions was commenced, the pulse continued to fall gradually, and at one time, when the respirations rose to 54 from 35, there was no change noticed in the pulse or pupils. Case 235 shows a similar case, and also the accidental occurrence of an overdose of ether at the half hour. After the anæsthesia was stopped the respirations fell to normal, and the pulse went up a little. Although these reflexes were present in all cases tested, the intensity of them varied very much.

Some individuals show a special susceptibility to the action of ether in the form of an extremely sensitive respiratory mucous membrane, which is intensely irritated by even a very low percentage of vapor. The respirations are very rapid in these cases, and the slightest increase in the strength of vapor causes coughing even under deep anæsthesia. Case 228, total extirpation of the uterus, is one in which this was present to a moderate degree. The pulse rise shown towards the end of operation appeared due to the high rate of respiration, as there was nothing else to account for it. This case was very similar to No. 244, already referred to, where we have a very different tracing both of pulse and respiration. In Cases 225 and 252 this idiosyncrasy, if such we may call it, was present to a marked degree. They show two administrations, at an interval of two months, to the same patient; and here there was the condition described, and although every means was tried in the way of regulating the amount of ether vapor exhibited, it was found impossible to keep up the anæsthesia without causing the high respiration and pulse-rate shown. Almost immediately after ceasing the administration, however, the pulse and respirations are seen to have come down to normal.

The Character of the Pulse.—On placing the fingers on the radial artery during ether anæsthesia, one notices that there is something peculiar in the character of the pulse-wave, the tension seems to be rather high and sustained, and yet there is not the sensation of a forcible rise and slow and gradual fall given by the ordinary high-tension pulse. The cause of this peculiarity is shown in the following sphygmograms, which were taken at intervals during the anæsthesia by Dr. Kenneth Cameron and myself. The tracings were made by the Marey sphygmograph

placed upon the radial artery; and all those from the same case were taken without any readjustment of the instrument, so as to secure uniform pressure; and at the quarter hours to correspond with the pulse-respiration charts which I append. Each sphygmogram is lettered to correspond with the lettering on the chart,

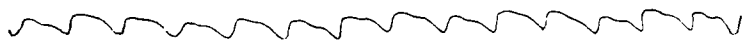


and has marked on it the time at which it was taken and the respiration and pulse-rate.

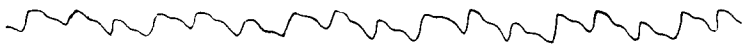
CASE 247. *Operations on the Cervix and for the Repair of the Perineum.*—The only unusual feature in the case was a copious secretion of viscid mucus, which collected in the air-passages, and so seriously interfered with respiration that at one and a half hours the anæsthesia was allowed to pass off sufficiently to induce

vomiting, in the hope of getting rid of some of the mucus by that means.

Sphygmogram *A* was taken at the half-hour. A few minutes later the ether vapor was doubled in strength, and given thus for two minutes when *B* was taken. The pulse is seen to have risen

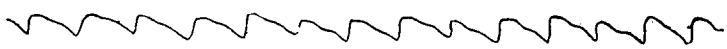


247 *A.*



247 *B.*

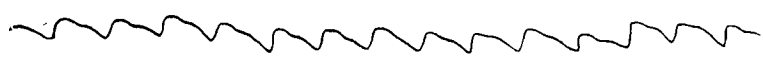
18, the respirations 8 to the minute, and the pupils became widely dilated. The apparent irregularity of the pulse is probably due entirely to movements of the patient's arm caused by the deep respirations. The character of the pulse-wave is not changed.



247 *C.*

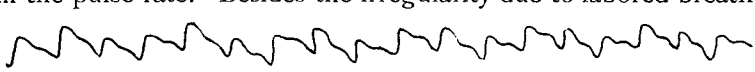
247 *D.*

C, *D*, and *E* were taken at three-quarters, one, and one and a quarter hours. *C* shows that the effect of the overdose of ether given at *B* has passed off.



247 *E.*

F was immediately after retching had been induced by stopping the ether. As no breathing occurred during the attempts at vomiting, there was considerable blueness of the face and increase in the pulse-rate. Besides the irregularity due to labored breath-

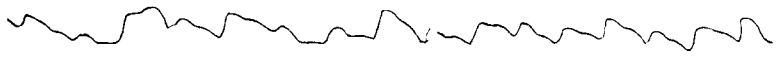


247 *F.*

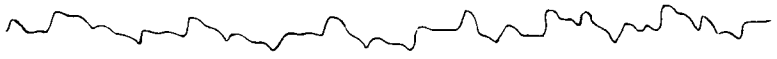
ing, note that the upward stroke of the lever is almost straight, as compared with the oblique or curved rise shown in the others.

In *G* and *H*, taken one and a half and one and three-quarters hours, the breathing was choked and labored from the mucus in

the throat. The patient was being drowned in her own secretions. As the mucus was out of reach of a sponge passed into the



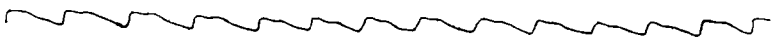
247 *G.*



247 *H.*

throat, vomiting was again induced, and this time a considerable amount expelled.

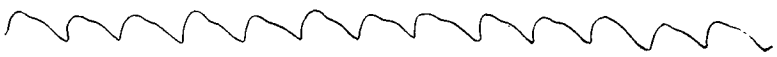
K is taken from the same patient ten days after operation, and shows a moderately high-tension pulse.



247 *K.*

CASE 248. *Operations upon the Cervix and for Hæmorrhoids.*—The pulse-respiration chart shows an average case with the usual reflex quickening of the breathing. There was no mucus.

248 *A.*



248 *C.*

A and *C*, the half and three-quarters hour, show the same general character found in all the tracings taken under ether. The ascent is curved, the lever at first rises rapidly, then more slowly, and does not reach its highest point until one-quarter of the whole time occupied by the beat has passed. The descent is just as gradual, with a barely perceptible pause in the fall representing the dicrotic wave.

248 *D.*

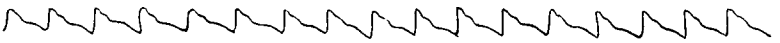
D, taken after two minutes of double the usual dose of ether, shows the alternate beats large and small. Here exactly

the same effect was observed as in 247 *B*. The rise in pulse-rate is 14, and in respirations 13 to the minute.

248 *E*.

248 *F*.

E and *F* show the pulse-wave at one and one and a quarter hours to be exactly similar to those taken earlier in the operation.



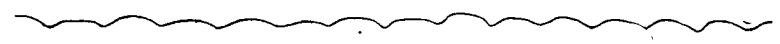
248 *G*.

G was taken the day following the operation, and the straight, almost vertical ascent with immediate fall and dicrotic and predicrotic waves are in sharp contrast with the same pulse under ether.

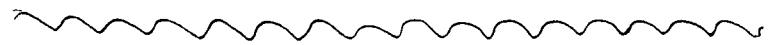
CASE 249, *Plastic operations on the cervix and of vagina*, shows five tracings taken at quarter-hour intervals, beginning at the three-quarter hour.

249 *A*.

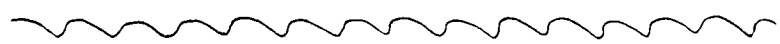
249 *B*.



249 *C*.



249 *D*.

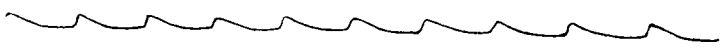


249 *E*.

There was the same difficulty with stiff mucus in the throat in this case as in No. 247. The curve in the first three tracings is simply a gradual rise and somewhat more gradual fall. The other two resemble the other cases, but there is no trace of the dicrotic wave in any of them.

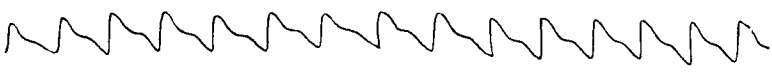
CASE 250. *Cervix and Ovariotomy.*—The first tracing was taken fifteen minutes after the ether was stopped and the second twenty-four hours later. In the first, the curved ascent as seen under ether has already begun to pass off, but the highest pressure is maintained for nearly half the beat, and there is no dicrotic wave. The second is a normal tracing.

249 *F.*

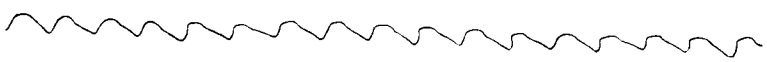


250 *A.*

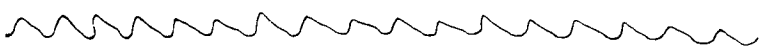
CASE 251. *An Operation for Hæmorrhoids in a very Anæmic Girl.*—The three-quarter-hour tracings, *A*, *B*, and *C*, resemble No. 248.



250 *B.*



251 *A.*



251 *B.*

D, taken three days later, shows a moderate tension pulse met with during fever, which is here seen to be 99.4° F. The absence of any dicrotic wave is remarkable.

251 *C.*

251 *D.*

The series of sphygmograms shown are not selected, but are taken from five consecutive cases. They all show the same general character, and are, as far as I know, totally unlike those obtained during health or in disease. The chief points of dif-

ference are the entire absence of straight lines and sharp angles, and the more or less complete obliteration of the dicrotic wave. In the present state of our knowledge the exact conditions of the circulation, which this form of sphygmogram denotes, cannot be positively stated. I am inclined to attribute it to high arterial tension with a slowly-acting heart. The absence of the dicrotic wave points to high tension and to that increased blood-pressure which has been shown to be present during the inhalation of ether. The curved ascent of the wave, I think, is best explained by a slowly-acting ventricle, which, on purely theoretical grounds, one would be inclined to expect under deep anæsthesia. What ever the explanation, the state of the circulation under ether anæsthesia is shown to be profoundly modified.

The practical points suggested by the consideration of this part of the subject are these:

(1) That there are certain reflexes, present during full surgical anæsthesia, which manifest themselves by increasing the rate and the depth of the respirations.

(2) That the production of these reflexes does not affect the pulse, pupils, or general condition of the patient.

(3) That during their occurrence the amount of ether being inhaled should be temporarily diminished; as the increased frequency and depth of respiration would otherwise lead to an overdose being exhibited.

(4) That the pulse and respiration, if watched from the outset, are a valuable indication of the degree of anæsthesia present; and that quickening, especially of the respirations, denotes an overdose of ether unless it is accounted for by the reflexes mentioned or by interference with the breathing from the presence of mucus in air-passages.

(5) That quickening of the pulse alone denotes hæmorrhage.

The Condition of the Pupils.—The pupils are usually moderately contracted and react actively to light, there are, however, noticeable variations in size from time to time which cannot be easily accounted for. An overdose of ether causes wide dilatation and partial loss of the light reflex; a partial degree of asphyxia, from the admission of too little pure air, causes fine con-

traction. It is not uncommon to find the pupil which has been frequently examined smaller than the other; the repeated exposure here causes a certain amount of permanent contraction. I strongly deprecate the practice of repeatedly testing for the presence of the corneal reflex; it is rarely necessary to do so more than once, and often I omit it altogether. The rate and especially the character of the breathing are a reliable index to the occurrence of full anæsthesia, even at the outset of the administration; and after that, as has been already shown, they are the best evidence to go by.

The Reflexes.—I have not as yet collected sufficient data on which to base any general statement. There appears, however, to be a period, during the production of anæsthesia, in which the knee-jerk is increased and ankle clonus is present. As I insist on absolute quiet and non-interference with the patient during the production of the anæsthesia, the reflexes were not examined until the breathing denoted insensibility. Similarly there is a period during recovery in which there is increased knee-jerk and ankle clonus.

Reflexes during deep anæsthesia, as before described, are obtained from the anus, rectum, ovaries, testes, perineum, and peritoneum.

Secretion of Mucus in the Respiratory Tract.—The collection of a large amount of sticky mucus in the larynx and pharynx during anæsthesia very often seriously interferes with the breathing, especially where the nature of the operation necessitates the supine position. In 7.5 per cent. of the cases I noted the presence of mucus in sufficient quantity to cause some difficulty. Its removal is usually readily effected by a small sponge fixed on a holder thrust into the pharynx; where this fails, it is well to have the patient recover sufficiently to allow of vomiting being induced by tickling the pharynx with the sponge. The act of vomiting forces the mucus out of the upper part of the trachea and larynx, and it can be induced before the patient has regained consciousness.

Before leaving this part of the subject, let us contrast this, which I will call the rational method of ether administration, with

that in general use. I contend that ether, like all other powerful drugs, should be given in doses just sufficient to bring about the required result, and no more. How do we attain this in other cases? The maximum and minimum dose has been determined, and in giving a drug we use our judgment with regard to the first dose, and alter this to more or less according to the result obtained. It is hardly necessary to point out that no data on which to base the strength of subsequent doses can be obtained unless the amount actually taken into the body is known. When one, wishing to produce a definite physiological action by a certain drug, orders an ounce of it to be taken in a wineglass of water, and returns the following day to find that an unknown proportion was spilt in the act of administering it, one has absolutely no data on which to base one's further procedure in the case; unless the desired action is already present, and then the only knowledge gained is that something less than the ounce was sufficient to produce it, but whether just enough or more than was necessary has been taken, it is impossible to tell. Now this represents fairly well what occurs when ether is administered by those forms of inhaler which consist essentially of a sponge, gauze pad, or other means of holding the ether with a more or less accurately-fitting mask; the commonly-used "cone" is the best known type. No attempt is made or can be made to measure the actual amount of ether inhaled, and it is wellnigh impossible to regulate the strength of vapor, owing to the extremely volatile nature of the drug. The amount "spilt" on expiration must be very large, but is always an unknown quantity, consequently, although the administrator acquires by long experience a certain degree of exactness in determining the amount of ether to keep pouring into the inhaler, he is never able to tell what proportion of this the patient has actually inhaled, and the most he can do is either to continuously exceed the necessary amount or to run the risk of frequently having the anæsthesia partially pass off. But, as I have shown, by using Clover's inhaler the anæsthetist can measure the amount inhaled, and can regulate the further administration in exact proportion to the effects produced.

There are three principal points to be considered in discussing the advantages of any inhaler; its safety, the patient's comfort, and the administrator's comfort. With regard to the first of these, we are here able to give the minimum dose necessary to produce the required effect, and the pulse-respiration charts are evidence of the patient's condition. The extremely slight liability to vomiting on the operating table is also important, as a large percentage of the fatal results recorded have been due to this cause. That the patient's comfort is considered is seen in the absence of struggling during the administration, and in the preference expressed for this inhaler by those who have tried others. It is a most significant fact, too, that where there had been no previous experience of other inhalers, I rarely had any trouble in giving the ether, and never in repeating the administration after once using this one. In considering the administrator's comfort, it must be remembered that in profound anæsthesia, a state but little removed from death, constant watchfulness is essential to detect any dangerous symptoms. The state of the respiration has been shown to be the most reliable evidence of the patient's condition, and with this inhaler we have the means of accurately observing this. The filling and collapsing of the bag show the actual amount of air entering the lungs, and the noise produced by the breath in passing through the ether reservoir enables the ear to detect the slightest obstruction to the breathing or alteration in its character. This, too, is an additional element in regard to its safety. Other advantages are, rapidity in the production of anæsthesia, the small amount of ether used, and the relatively slight escape of ether vapor into the room. I do not claim that, with statistics of only 300 cases to draw from, the dose can at present be positively stated, but I do think that by careful observation, and the collection of a large number of cases, we will yet be able to fix the dose for the required time, and administer it in a rational manner. May it not be that failure to recognize the existence of those respiration reflexes, before described, has been in a considerable measure accountable for the increased risk attending anæsthesia in operations on the rectum and anus? The administrator, considering the quickening of the breathing

to show partial recovery of the patient, increases the amount of the anæsthetic given, and this is taken up quickly, owing to the increased depth and rate of respiration, and leads to an overdose, which, in chloroform especially, is so often followed by fatal consequences.

The Urine.—The effect produced by ether anæsthesia upon the secretion and composition of the urine was arrived at by the following method of investigation. Examinations were made of—

(1) A specimen of urine obtained just before commencing the administration, designated "*ante*" in my notes.

(2) The urine secreted during the anæsthesia, drawn off by catheter immediately after ceasing the administration, and before the patient had been removed from the operating table, designated "*post.*"

(3) One or more specimens obtained from twelve hours to five days after the operation, and designated by the number of hours after.

The *ante* specimen was examined as a control for those cases in which abnormal constituents were found *post.*

For the *post* the points recorded are: amount, odor, specific gravity, presence of albumen, acetone, sugar, and the total amount of urea in grains. The other specimens were treated more especially for albumen, sugar, and acetone.

The following tests were made use of:

Albumen.—Overlaying cold nitric acid with the urine. Boiling of the upper portion of urine in a small calibre test-tube with the subsequent addition of nitric acid. Where present, the quantity was estimated by Esbach's albumenometer.

Sugar.—By freshly-prepared Fehling's solution.

Acetone.—By testing the distillate with Lieben's iodoform test. A practical difficulty experienced at first in making this test is worth noting. I found that in distilling one specimen containing acetone, a considerable quantity of it had lodged in the tube (worm) of the condenser, and was carried over with the next distillate. This was overcome by drawing off the cold water from the condenser, and passing steam through the tube after each distillation.

Urea was estimated with the ureometer of Doremus, by the decomposition of sodium hypobromide.

Deposits.—By the microscope and chemical tests.

The *amount of urine secreted* while in a state of anæsthesia was 256.85 fluid ounces in 100 cases, lasting 9130 minutes,—that is, 2.5 ounces in an hour and a half, or at the rate of 40.5 ounces in twenty-four hours. This is within the average normal amount. It is found, too, that the amount varies with the length of the anæsthesia, becoming relatively less as the time is lengthened thus.

TABLE II.

29 cases lasting one hour or under, averaged	. .	2.6	ounces	per	hour.
50 " between one and two hours "	. .	1.9	"	"	"
30 " " two and three hours "	. .	1.42	"	"	"

The amount secreted depended largely too upon the character of the ante specimen; thus, in extremely nervous patients and where there was a large amount of ante of low specific gravity, the post was of similar character. There was no instance of entire suppression, but in two or three cases, where the anæsthesia lasted between one and two hours, only a couple of drachms was obtained, in these, however, it is probable that the bladder was not properly emptied at the time. Later experience showed that, unless pressure is made over the bladder above the pubes, a portion of the urine may remain in the organ even after catheterization.

The total amount of *urea* in the same 100 cases was 1122.8 grains,—that is, at the rate of 177.08 grains *per diem*,—about three-eighths of the normal amount. As one would expect, there is a gradual diminution in the amount secreted as the time passes; thus long anæsthesias show a smaller amount per hour than short ones. This fact is well shown by the table given (III), and also by the following case: No. 241, duration 135 minutes. At the end of 60 minutes 1¾ ounces of urine were drawn off, and found to contain 9 grains of urea; 75 minutes later, 2 ounces more were obtained; but, although the interval was longer, and the quantity proportionately increased, there was only 7.2 grains of urea present.

TABLE III.

29 cases, one hour and under,	averaged . .	10.75 grains per hour.
50 " between 1 and 2 hours,	" . .	7.34 + " " "
20 " " 2 " 3 "	" . .	5.68 + " " "

Albumen was detected *post* in 7 of 100 cases, in which it had been absent *ante;* and it disappeared again within 48 hours in every case. The cases are given in detail.

No. 122. Anæmic woman, blood-count showing 3,800,000 red and 37,600 white per centimetre. Duration of anæsthesia 120 minutes. Operation on cervix and ligaments. Urine, *post*, three fluid ounces, acid, clear, uric acid sediment; contains 16.5 grains urea and albumen, one-eighth bulk on boiling with nitric acid; 24 hours later only a slight trace of albumen was present, and 48 hours, no albumen.

No. 127. Same patient, twelve days later, duration ninety minutes. Operation on perineum. Urine, *post*, 3.5 ounces; again containing albumen, one-tenth bulk, which disappeared by the second day.

No. 134. Total extirpation of the uterus. One hundred and sixty minutes. Urine, four ounces, contained a trace of albumen; not present the following day.

No. 141. Operation on perineum, 130 minutes. Urine, 5.5 ounces, contains albumen less than 1 in 1000.

No. 185. Total extirpation of the uterus, 225 minutes. Urine, 2.25 ounces, contains a trace of albumen.

No. 190. Operation on the perineum, 160 minutes. Urine, three ounces, contains albumen less than 1 in 1000. Esbach: Twenty-four hours later, no albumen present.

No. 228. Total extirpation of the uterus, 165 minutes. Urine, one ounce, contains albumen 2 in 1000. Esbach: This had disappeared in a couple of days.

In all the above cases microscopical examinations were made of the sediment, but no casts or other evidences of renal disease were discovered. It is to be noted that three of the above cases were total extirpation of the uterus in which a sound was introduced into the bladder during the operation. In a large number of cases a trace of albumen was found the second or third day after

operation, due to the vaginal discharge. The small amount and transient nature of the albuminuria present in these cases, together with the absence of any signs of renal disease, plainly show it to have been due to changes in the circulation at the time.

The presence of *acetone* was not suspected at first, and consequently not looked for until discovered accidentally. Then seventy-five consecutive cases were examined, and it was found in all within twenty-four hours after the anæsthesia. Table IV shows the percentage of cases giving acetone at various intervals after anæsthesia.

TABLE IV.

Post.	58 tested.	Acetone present in	37	=	64 per cent.
24 hours.	54 "	" "	" all	=	100 " "
48 "	17 "	" "	" all	=	100 " "
72 "	20 "	" "	" 17	=	85 " "
96 "	9 "	" "	" 6	=	66 " "
120 "	5 "	Slight trace in	3	=	60 " "

Acetone is thus seen to be a constant product of ether anæsthesia, but I think of little or no clinical significance.

A decided *odor of ether* was noticed in all the *post* specimens, whether acetone was present or not. It was not, however, distinguishable in specimens obtained afterwards, although it remained for weeks in the *post* if tightly corked up. It was probably due to ether excreted in the urine while the body tissues were saturated with the drug. By slowly distilling a number of *post* specimens at a very low temperature, and passing the vapor through alcohol, the alcohol became strongly impregnated with the odor of ether.

Squibb's ether was used in every administration.